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DEFECT ESTIMATION for WHITE FIR in the FREMONT NATIONAL FOREST

Paul E. Aho
Philip Simonski

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PORTLAND, OREGON

Paul E. Aho is plant pathologist, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oregon.

Philip Simonski is timber inventory project leader, Fremont National Forest, Lakeview, Oregon.

DEFECT ESTIMATION FOR WHITE FIR IN THE FREMONT NATIONAL FOREST

Reference Abstract

Aho, Paul E., and Philip Simonski.
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Two methods for estimating defect in standing white firs are presented for use by timber cruisers in the Fremont National Forest. Defect percentages of gross merchantable cubic-foot and Scribner board-foot volumes are tabulated by d.b.h. only and also by age and d.b.h. Constant defect percentages must then be added for various indicators. The multiple regression equations used to derive the tables are provided. Average length deductions below and above major indicators plus flat percentage factors for hidden defect are presented.

Keywords: White fir, *Abies concolor*, Indian paint fungus, *Echinodontium tinctorium*, defect deduction(-merchantable volume.

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RESEARCH SUMMARY

White fir is an important commercial species in the Fremont National Forest. It has a reputation for being highly defective, mainly because of decay. Cruisers preparing inventory data and timber sales have been handicapped by lack of reliable methods for making defect deductions in their sample trees. Cull rules developed for true fir species in other areas in Oregon, Washington, and California are probably not applicable on the Fremont National Forest because defect usually varies considerably for a given tree species from one area to another.

In this paper two methods are presented for making defect estimates in standing white fir. (1) Defect percentages of gross merchantable volume of trees on the Fremont. Cubic-foot and Scribner board-foot volumes are tabulated by d.b.h. and age and by d.b.h. only. Constant defect percentages must be added for major indicators, which include Indian paint fungus conks, basal and trunk injuries, frost cracks, and dead or broken tops. Multiple regression equations used to derive the tables are provided. Since the equations can be easily used in computer programs, this method may be most applicable in large scale inventory surveys. (2) Average length deductions below and above major indicators plus flat percentage factors for hidden defect. This method may be most useful to cruisers determining net volumes of sample trees in timber sales.

Introduction

Reliable methods for estimating defect in standing white fir trees, *Abies concolor* (Gord. & Glend.) Lindl., are needed by cruisers in the Fremont National Forest. Two methods have been developed for estimating defect in grand fir trees, *A. grandis* (Dougl.) Lindl., in the Blue Mountains of Oregon and Washington (Aho 1974). However, these methods are applicable only to the area in which the study was made, because decay usually varies significantly from one geographical area to another (Wagener and Davidson 1954).

The objective of this paper is to present two methods for estimating defect in standing white firs on the Fremont National Forest: (1) Indicator defect percentages, and (2) indicator length deductions with flat percentage factors for "hidden" defect.

1. Multiple regression equations were developed which related cubic- and board-foot defect percentages to tree age and d.b.h. and visible defect indicators.

2. Average length deductions below and above reliable indicators of defect were calculated and flat percentage factors were determined to account for "hidden" defect, which is defect not associated with the major visible indicators used in this study.

The first method is probably most applicable to regional and forest inventories, because the estimating equations can be easily used in computer programs designed to compile survey data from large areas. Since it is only necessary to record tree age, d.b.h., and presence of reliable defect indicators, the use of equations eliminates the subjectivity of cruisers attempting to cull portions of trees based on location of defect indicators.

The second method may be most useful in determining net volumes of sample trees in timber sale areas. Timber sales are generally local and are often carried out by cruisers with years of experience in these localities. Thus, the average length deductions below and above indicators can be adjusted by cruisers familiar with local defect conditions.

Methods

A total of 133 white firs were selected for study in 18 widely distributed mature (60-149 years) and overmature (150-400 years) stands in the Fremont National Forest (fig. 1). Numbers of trees with various major and minor indicators as well as trees without indicators are listed by diameter classes (table 1). Major indicators of defect were presumed to be the same for white fir on this forest as those previously determined for grand fir in the Blue Mountains and included: Indian paint fungus (*Echinodontium tinctorium* Ell. and Ev.) conks (fig. 2), basal injuries more than 10 years old (fig. 3), trunk wounds more than 10 years old or 1 foot long (fig. 4), frost cracks (fig. 5), and dead (fig. 6) or broken tops (fig. 7). Since decay may at times be associated with minor indicators, such as forks, crooks, dead vertical branches, and small and recent (less than 10 years old) injuries, trees with these indicators were also studied (see Aho (1974) for description and illustration of the minor indicators).

Standing trees selected for study were carefully examined for indicators. D.b.h., location, and description of defect indicators were noted. The trees were then felled, dissected, and examined for decay and other defects. Tree age was determined by a ring count at stump height. Procedures for measuring log and defect volumes and length deductions below and above indicators were the same as those used in the grand fir study in the Blue Mountains (Aho 1974).

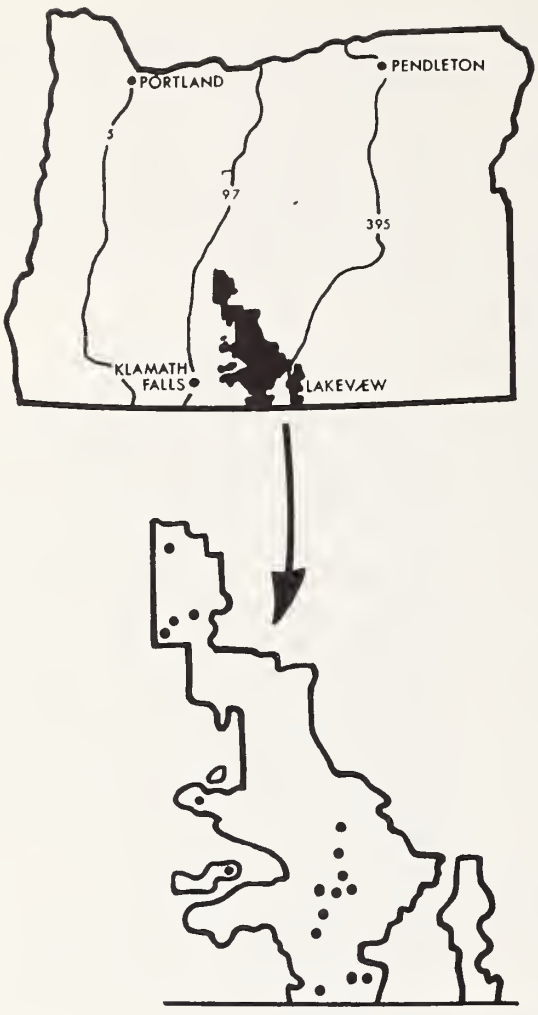

Figure 1.--Location of Fremont National Forest in Oregon and localities where study trees were sampled.

Table 1.--*Distribution of various types of indicators on study trees by d.b.h. classes*

D.b.h. class	Number of sample trees	Trees without indicators	Trees with major indicators					Trees with minor indicators			
			Indian paint fungus conks	Basal injuries	Trunk injuries	Frost cracks	Dead or broken tops	Forks	Crooks	Dead vertical branches	Injuries 1 foot long or 10 years old[1/]
			Number								
5.0-10.9	11	2	0	1	2	2	2	0	1	0	4
11.0-14.9	23	7	4	3	3	5	6	0	1	0	6
15.0-18.9	37	3	6	11	6	12	6	0	1	4	1
19.0-22.9	27	2	6	11	5	13	4	1	0	0	1
23.0-26.9	17	3	8	6	1	9	1	1	0	0	0
27.0-30.9	10	0	4	2	2	5	2	2	1	1	2
31.0-34.9	6	3	2	2	0	2	0	0	0	0	0
35.0-38.9	1	1	0	0	0	0	0	0	0	0	0
39.0+	1	0	1	0	0	0	0	0	0	0	0
Total	[2/] 133	21	31	36	19	48	21	4	4	5	14

[1/] Includes basal or trunk injuries less than 10 years old and trunk wounds less than 1 foot long.

[2/] Number of trees with various indicators will not total 133 because some trees had more than 1 type of indicator.

Figure 2.--Indian paint fungus conks on a white fir. They are the most important indicator of decay in this species on the Fremont National Forest. When located in the living crown, they can be easily overlooked. Since they do indicate the presence of considerable amounts of decay, cruise results may be significantly affected if conks are missed.

Figure 3.--Old basal wound on white fir. Basal injuries include open or closed wounds, which are in contact with the ground, caused by fire, root rots, falling trees, or mechanical logging equipment. Inconspicuous, old basal injuries nearly grown over may be overlooked if sample trees are not examined carefully.

Figure 4.--Trunk wound on a white fir. Trunk injuries include open or closed wounds below the merchantable top but not in touch with the ground. They may be caused by falling trees, lightning, animals, or logging equipment. Ignore trunk injuries less than 1 foot long or less than 10 years old when computing defect.

Figure 5.--Frost crack on a white fir. Frost cracks are open or closed scars or seams caused by freezing. They are often associated with wetwood, a condition of excessive moisture in the heartwood, usually in the butt log. Bleeding frost cracks at the base of a tree often indicate Indian paint fungus conks higher up the tree.

Figure 6.--White fir with dead top. Recently killed tops should be ignored in computing defect.

Figure 7.--White fir with a broken top. Ignore those recently broken when computing defect.

Defect for cubic-volume measure includes decay only. For board-foot measure, decay, shake, check, and frost cracks are included. No log cull rules were used in cubic-volume defect measurements. In board-foot measurements, logs more than two-thirds defective were considered cull except where merchantable portions of a defective log could be attached to an adjacent sound log.

Multiple regression equations were derived for estimating cubic- and board-foot defect percentages for individual trees. The estimating equations and tables of defect percentages calculated from the equations are presented in this paper.

Defect Estimation in Individual White Firs

Indicator defect factors for white fir on the Fremont National Forest are presented as (1) percentages of gross merchantable tree cubic-foot and Scribner board-foot volumes and (2) average length deductions below and above indicators, with flat percentage factors for hidden defect. Accurate application of both kinds of defect factors requires familiarity with the definitions of cubic- and board-foot defect and knowledge of indicators associated with defect as previously described in this paper (also see Aho (1974)). Both defect estimating methods will be more accurate when applied to large numbers of trees, although fairly accurate results may be obtained with small samples. In a given timber cruise, only one of the defect estimation methods should be selected; they cannot be used together.

INDICATOR PERCENTAGE DEFECT FACTORS

Defect percentages derived from multiple regression equations (see table 2, footnote 1; and table 3, footnote 1) are tabulated by d.b.h. and age (tables 2 and 3). Since it is not always possible to obtain tree ages while cruising, defect percentages are also tabulated by d.b.h. only (tables 4 and 5). Constant defect percentages should be added to those obtained from these tables when various indicators are present.

If equations are to be used in a computer program, it should be realized that defect percentages computed from some combinations of d.b.h., age, and indicators can be less than zero or greater than 100 percent. These percentages should be set at zero or 100 percent.

Application of percentage defect factors.-- Sample trees should be carefully examined and the presence of reliable indicators (see figs. 2-7) noted. D.b.h. and age should be measured or estimated. Defect percentages for each tree can then be determined from table 2 or 3 or calculated from the equations in footnote 1 of these tables.

For example, to determine the cubic- and board-foot defect percentages for a 20-inch, 200-year-old white fir without any reliable indicators, simply look at the appropriate columns in the tables. This tree would have deductions of 3 percent of its gross merchantable cubic-foot volume (table 2) and 9 percent of its Scribner board-foot volume (table 3). If the same tree had one or more Indian paint fungus conks and an old broken top, it would be necessary to add 28 percent for the conks and 9 percent for the broken top to the 3-percent deduction previously obtained from table 2 for a total cubic-foot deduction of 40 percent. The additional deductions for these indicators in board-foot measure would be 57 percent for the conks and 4 percent for the broken top for a total board-foot deduction of 70 percent.

Table 2.--*Defect expressed in percent of gross merchantable cubic-foot volume for white fir trees on the Fremont National Forest by age and d.b.h.*[1/] *Add these constants for each type of defect indicator present: 1 or more Indian paint fungus conks 28 percent, basal injuries 4 percent, trunk injuries 4 percent, frost cracks 5 percent, and dead or broken tops 9 percent*

Tree d.b.h. (inches)	Tree age (years)																	
	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400
	Percent																	
5	0	1	2	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
6	0	1	2	3	4	5	7	8	9	10	11	12	13	14	15	17	18	19
7	0	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
8	0	0	1	2	4	5	6	7	8	9	10	11	12	14	15	16	17	18
9	0	0	1	2	3	4	5	7	8	9	10	11	12	13	14	15	17	18
10	0	0	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17
11	0	0	0	1	3	4	5	6	7	8	9	10	11	13	14	15	16	17
12	0	0	0	1	2	3	4	6	7	8	9	10	11	12	13	14	16	17
13	0	0	0	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16
14	0	0	0	0	2	3	4	5	6	7	8	9	10	12	13	14	15	16
15	0	0	0	0	1	2	3	4	6	7	8	9	10	11	12	13	14	16
16	0	0	0	0	1	2	3	4	5	6	7	9	10	11	12	13	14	15
17	0	0	0	0	0	2	3	4	5	6	7	8	9	10	12	13	14	15
18	0	0	0	0	0	1	2	3	5	6	7	8	9	10	11	12	13	15
19	0	0	0	0	0	1	2	3	4	5	6	8	9	10	11	12	13	14
20	0	0	0	0	0	1	2	3	4	5	6	7	8	9	11	12	13	14
21	0	0	0	0	0	0	1	2	4	5	6	7	8	9	10	11	12	14
22	0	0	0	0	0	0	1	2	3	4	5	7	8	9	10	11	12	13
23	0	0	0	0	0	0	1	2	3	4	5	6	7	8	10	11	12	13
24	0	0	0	0	0	0	0	1	2	4	5	6	7	8	9	10	11	12
25	0	0	0	0	0	0	0	1	2	3	4	5	7	8	9	10	11	12
26	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	10	11	12
27	0	0	0	0	0	0	0	0	1	3	4	5	6	7	8	9	10	11
28	0	0	0	0	0	0	0	0	1	2	3	4	6	7	8	9	10	11
29	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	9	10	11
30	0	0	0	0	0	0	0	0	0	2	3	4	5	6	7	8	9	10
31	0	0	0	0	0	0	0	0	0	1	2	3	5	6	7	8	9	10
32	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	8	9	10
33	0	0	0	0	0	0	0	0	0	0	2	3	4	5	6	7	8	9
34	0	0	0	0	0	0	0	0	0	0	1	2	3	5	6	7	8	9
35	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	8	9
36	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8
37	0	0	0	0	0	0	0	0	0	0	0	1	2	4	5	6	7	8
38	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	7	8
39	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7
40	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4	5	6	7

[1/] Derived from the equation:

$$P_c = -1.425 + 0.056A + 3.727B + 27.910C - 0.346D + 4.156E + 5.254F + 9.038G$$

where A = tree age; B = 1 if 1 or more basal injuries present, 0 if no basal injuries present; C = 1 if 1 or more Indian paint fungus conks present, 0 if no conks present; D = tree diameter outside bark at breast height; E = 1 if 1 or more trunk injuries present, 0 if no trunk injuries present; F = 1 if 1 or more frost cracks present, 0 if no frost cracks present; G = 1 if broken or dead top present, 0 if no broken or dead top present.

Table 3.--*Defect expressed in percent of gross merchantable Scribner board-foot volume for white fir trees on the Fremont National Forest by age and d.b.h.*[1/] *Add these constants for each type of defect indicator present: 1 or more Indian paint fungus conks 57 percent, basal injuries 11 percent, trunk injuries 8 percent, frost cracks 19 percent, and broken or dead tops 4 percent*

Tree d.b.h. (inches)	Tree age (years)																	
	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400
	Percent																	
11	3	6	8	11	13	16	18	21	23	26	28	31	33	36	38	41	43	46
12	2	5	7	10	12	15	17	20	22	25	27	30	32	35	37	40	42	45
13	1	3	6	8	11	13	16	18	21	23	26	28	31	33	36	38	41	43
14	0	2	5	7	10	12	15	17	20	22	25	27	30	32	35	37	40	42
15	0	1	3	6	8	11	13	16	18	21	23	26	28	31	33	36	38	41
16	0	0	2	5	7	10	12	15	17	20	22	25	27	30	32	35	37	40
17	0	0	1	3	6	8	11	13	16	18	21	23	26	28	31	33	36	38
18	0	0	0	2	4	7	9	12	14	17	19	22	24	27	29	32	34	37
19	0	0	0	1	3	6	8	11	13	16	18	21	23	26	28	31	33	36
20	0	0	0	0	2	4	7	9	12	14	17	19	22	24	27	29	32	34
21	0	0	0	0	1	3	6	8	11	13	16	18	21	23	26	28	31	33
22	0	0	0	0	0	2	4	7	9	12	14	17	19	22	24	27	29	32
23	0	0	0	0	0	1	3	6	8	11	13	16	18	21	23	26	28	31
24	0	0	0	0	0	0	2	4	7	9	12	14	17	19	22	24	27	29
25	0	0	0	0	0	0	1	3	6	8	11	13	16	18	21	23	26	28
26	0	0	0	0	0	0	0	2	4	7	9	12	14	17	19	22	24	27
27	0	0	0	0	0	0	0	0	3	5	8	10	13	15	18	20	23	25
28	0	0	0	0	0	0	0	0	2	4	7	9	12	14	17	19	22	24
29	0	0	0	0	0	0	0	0	0	3	5	8	10	13	15	18	20	23
30	0	0	0	0	0	0	0	0	0	2	4	7	9	12	14	17	19	22
31	0	0	0	0	0	0	0	0	0	0	3	5	8	10	13	15	18	20
32	0	0	0	0	0	0	0	0	0	0	2	4	7	9	12	14	17	19
33	0	0	0	0	0	0	0	0	0	0	0	3	5	8	10	13	15	18
34	0	0	0	0	0	0	0	0	0	0	0	1	4	6	9	11	14	16
35	0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	10	13	15
36	0	0	0	0	0	0	0	0	0	0	0	0	1	4	6	9	11	14
37	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	10	13
38	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	6	9	11
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	10
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	6	9

[1/] Derived from the equation:

$$P_b = 9.575 + 0.125A + 11.338B + 56.981C - 1.282D + 8.091E + 18.637F + 3.803G$$

where A = tree age; B = 1 if 1 or more basal injuries present, 0 if no basal injuries present; C = 1 if 1 or more Indian paint fungus conks present, 0 if no conks present; D = tree diameter outside bark at breast height; E = 1 if 1 or more trunk injuries present, 0 if no trunk injuries present; F = 1 if 1 or more frost cracks present, 0 if no frost cracks present; G = 1 if dead or broken trops present, 0 if no dead or broken tops present.

Table 4.--*Defect in percent of gross merchantable cubic-foot volume for white fir trees on the Fremont National Forest by d.b.h.*[1/] *Add these constants for each type of defect indicator present: 1 or more Indian paint fungus conks 29 percent, basal injuries 5 percent, trunk injuries 5 percent, frost cracks 6 percent, and dead or broken tops 9 percent*

Tree d.b.h. (inches)	Defect	Tree d.b.h. (inches)	Defect	Tree d.b.h. (inches)	Defect
	Percent		Percent		Percent
5	4	17	1	29	0
6	3	18	1	30	0
7	3	19	1	31	0
8	3	20	1	32	0
9	3	21	1	33	0
10	3	22	0	34	0
11	2	23	0	35	0
12	2	24	0	36	0
13	2	25	0	37	0
14	2	26	0	38	0
15	2	27	0	39	0
16	2	28	0	40	0

[1/] Derived from equation:

$$P_c = 4.467 + 4.619B + 29.326C - 0.182D + 4.558E + 6.177F + 9.297G$$

where B = 1 if 1 or more basal injuries present, 0 if no basal injuries present; C = 1 if 1 or more Indian paint fungus conks present, 0 if no conks present; D = tree diameter outside bark at breast height; E = 1 if 1 or more trunk injuries present, 0 if no trunk injuries present; F = 1 if 1 or more frost cracks present, 0 if no frost cracks present; G = 1 if broken or dead top present, 0 if no broken or dead top present.

Table 5.--*Defect in percent of gross merchantable Scribner board-foot volume for white fir trees on the Fremont National Forest by d.b.h.*[1/] *Add these constants for each type of defect indicator present: 1 or more Indian paint fungus conks 60 percent, basal injuries 14 percent, trunk injuries 9 percent, frost cracks 21 percent, and broken or dead tops 4 percent*

Tree d.b.h. (inches)	Defect	Tree d.b.h. (inches)	Defect	Tree d.b.h. (inches)	Defect
	Percent		Percent		Percent
11	13	21	4	31	0
12	12	22	3	32	0
13	11	23	2	33	0
14	10	24	1	34	0
15	9	25	0	35	0
16	8	26	0	36	0
17	7	27	0	37	0
18	6	28	0	38	0
19	5	29	0	39	0
20	4	30	0	40	0

[1/] Derived from equation:

$$P_b = 22.475 + 13.651B + 60.258C - 0.902D + 9.043E + 20.604F + 4.274G$$

where B = 1 if 1 or more basal injuries present, 0 if no basal injuries present; C = 1 if 1 or more Indian paint fungus conks present, 0 if no conks present; D = tree diameter outside bark at breast height; E = 1 if 1 or more trunk injuries present, 0 if no trunk injuries present; F = 1 if 1 or more frost cracks present, 0 if no frost cracks present; G = 1 if dead or broken top present, 0 if no dead or broken top present.

INDICATOR LENGTH DEDUCTIONS AND FLAT FACTORS FOR HIDDEN DEFECT

Estimates of net volumes in standing trees are often made by timber cruisers by deducting portions of the trees above and below visible indicators of defect. When "visible" defect has been deducted, it is then necessary to apply a flat factor to the total sample volume to account for "hidden" defect. Hidden defect includes shake and decay which are not associated with major indicators and also the small amounts of decay occasionally associated with minor indicators, such as forks, crooks, dead vertical branches, basal and trunk injuries less than 10 years old, and trunk injuries less than 1 foot long. Average length deductions are presented for the major defect indicators (table 6).

Table 6.--*Length deductions for the most reliable indicators of defect on white fir in the Fremont National Forest*

Indicator type	Trees with defect indicator	Average length deduction	
		Below indicator	Above indicator
		- - - - Feet - - - -	
Indian paint fungus conks	31	17	20
Basal injuries	36	--	6
Trunk injuries	19	3	2
Frost cracks	48	2	3
Dead or broken tops	21	3	--

Application of length deductions and flat factors for hidden defect.-- If a tree has a series of Indian paint fungus conks and a basal scar, deduct those portions of the tree from 17 feet below the lowest conk to 20 feet above the highest conk and from 6 feet above the top of the basal injury to the bottom of the first log (table 6). Where there are two or more indicators in a given segment of a tree, use the indicator that gives the greater deduction. If there is a frost crack near or within a series of Indian paint fungus conks, for instance, base the deduction on the conks. Do not apply the average length deductions to recently killed or broken tops, trunk or basal wounds less than 10 years old, or trunk injuries less than 1 foot long.

In summary, determine total net volume of the sample trees by using the indicator length deduction factors. Total net cubic-foot and Scribner board-foot volumes must then be further reduced by 1 percent and 2 percent, respectively, to account for hidden defect. This, plus any additional deductions for sweep, breakage in felling, and missing parts of trees (broken tops) gives the net sound volume of the sample.

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2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

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